



STANDARD 321-07

RANGE SAFETY GROUP

**COMMON RISK CRITERIA STANDARDS FOR NATIONAL TEST
RANGES**

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STANDARD 321-07

**COMMON RISK CRITERIA STANDARDS FOR NATIONAL TEST
RANGES**

JUNE 2007

Prepared by

**RANGE SAFETY GROUP
RISK COMMITTEE**

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CHANGES TO THIS EDITION

This document is an updated version of RCC Document 321-02 (Common Risk Criteria for National Test Ranges: Inert Debris). The following subparagraphs contain a summary of changes. Note: the use of the word “supplement” used herein refers to the companion (supplemental) document to RCC Document 321.

- a. Expanded Scope. The scope of the standard is expanded to include other flight hazards in addition to inert debris. It now addresses risks due to explosive debris, overpressure, and toxics. To accommodate this change, the Risk Committee recommends that casualty, rather than fatality, be the primary measure of risk and has defined acceptable casualty risk criteria. Fatality risk criteria remain as a supplemental measure of risk for those range operations that are dominated by fatality risk.
- b. New Hazard Thresholds. New hazard thresholds are defined to account for casualty risk. Debris fragment thresholds are provided for blunt trauma injuries and chunky penetrating injuries, and overpressure thresholds are provided for unsheltered and sheltered people. In addition, debris fragment thresholds for penetrating structures are updated to reflect the results of recent studies.
- c. Aircraft Vulnerability Thresholds. The aircraft vulnerability thresholds are revised to remove the excess conservatism. The previous standard defined a single threshold for all types of aircraft. A separate set of vulnerability models are defined for large commercial jet transports to represent the robustness of those aircraft more accurately.
- d. Ship Probability of Impact. The probability of impact criteria for ships is revised to be more in line with United Nations International Maritime Organization and current range practices.
- e. Manned Spacecraft Protection. The manned spacecraft protection policies and criteria are revised to remove excess conservatism and clear up inconsistencies in application. The probability of impact criterion is updated to reflect assumptions of space launch activity that are more realistic and to provide an equivalent level of protection as that afforded to mission essential personnel. As another means of reducing excess conservatism, an ellipsoidal minimum miss-distance volume is provided as an alternative to the spherical miss-distance presented in the previous standard.
- f. Catastrophic Risk Protection. This revision introduces the subject of catastrophic risk protection. Some provisional, advisory criteria are provided, as well as guidelines for analyzing and assessing catastrophic risk.
- g. Implementation Guidelines. A new chapter (Chapter 4) was added to the document 321-07 supplement to provide implementation guidelines for applying the criteria to address aggregation and accumulation of risk from the various hazards, multiple

phase/multiple launch missions, annual risk management, and catastrophic risk. It also provides guidance on determining the beginning and end of a mission for applying the per mission criteria.

- h. Screening Criteria for Other Hazards. A new chapter (Chapter 8) was included in the 321-07 supplement to provide guidelines on screening criteria for casualty producing hazards such as Distant Focusing Overpressure (DFO), toxics, and radiation.
- i. Risk Management Process. The 8-step process for analyzing risk from inert debris is replaced with a more comprehensive overall range safety process that expands the concept to address hazards beyond just inert debris and includes the major activities required to conduct the entire risk management process. A checklist of factors and considerations was included to aid in proper execution of the process.
- j. Modeling Considerations. Two new chapters are added to the supplement providing advisory requirements for modeling tools (Chapter 3) and approaches and considerations for debris risk assessment model (Chapter 7)

FOREWORD

The Risk and Lethality Commonality Team (RALCT) was formed in 1996. The RALCT was formed for reaching a consensus on reasonable common standards for debris protection criteria and analytical methods. The initial version, RCC 321-97, was very useful, but was limited in scope due to the complexity of the subject and time constraints. This standard was updated in 1999 and again in 2002 to provide greater detail. In August 2004, the Range Commanders Council (RCC), Range Safety Group (RSG) determined that RCC Document 321-02 (Common Risk Criteria for National Test Ranges, Subtitle: Inert Debris), should be updated and expanded for other flight safety hazards (in addition to inert debris) and consequences potentially generated by range operations.

The RALCT became a standing committee under the RCC Range Safety Group in 2004. It was renamed the “Risk Committee” (RC) in February 2005 when work on this revision began in earnest. The Committee has updated RCC Document 321-02 to include:

- a. Risk acceptability criteria and supporting rationale for additional flight safety hazards and consequences potentially generated by range operations.
- b. The major activities required to conduct the entire risk management process and considerations to address hazards beyond just inert debris.
- c. Top-level requirements for computational models used to analyze the risks posed by inert and explosive debris.
- d. Updated hazard thresholds for inert and explosive debris, as well as screening criteria for other hazards including toxics, distant focusing overpressure, and ionizing and non-ionizing radiation.
- e. Factors and considerations for acceptable debris risk assessment models.

This document (RCC Document 321-07) is the basic document that defines consensus standards for the range risk management process and risk criteria. The companion document, RCC Document 321-07 (Common Risk Criteria for National Test Ranges: Supplement), provides additional detailed information to assist in implementation of the standards in the basic document. The criteria in this document should not be considered absolute; rather, this document and its supplement is intended to provide guidance on defining acceptable risks for hazardous range operations and to assist the user in developing more consistent risk assessments.

This document represents the collective efforts of both government and contractor personnel and is the result of an extensive cooperative effort.

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PREFACE

This document presents the results of Task RS-46, Range Safety Group (RSG) in the Range Commanders Council (RCC). Planned and unplanned hazardous events generated by flight operations present a safety concern for all test ranges. Each range has established its own set of criteria and analytical methods for protecting personnel, facilities, aircraft, and other assets from hazardous operations. Although these separate efforts have been very successful, the logical relationships among criteria used at the test ranges and across different hazards are often difficult to comprehend. The consensus standards presented in this document are intended to:

- a. Promote a uniform process among the ranges.
- b. Promote valid, repeatable risk assessments.
- c. Foster innovation to support challenging missions.
- d. Nurture openness and trustworthiness among the ranges, range users, and the public.
- e. Simplify the scheduling process.
- f. Present common risk criteria that can reduce cost for users of multiple test ranges.

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ACRONYMS

AFSPC	Air Force Space Command
AST	Associate Administrator for Space Transportation (FAA)
BMD	Ballistic Missile Defense
CFR	Code of Federal Regulations
COP	Critical Operations Personnel
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
ER	Eastern Range
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FTCA	Federal Tort Claims Act
FTS	Flight Termination System
GP	General Public
KSC	Kennedy Space Center
MEP	Mission Essential Personnel
MRTFB	Major Range and Test Facility Base
NASA	National Aeronautics and Space Administration
NAWC	Naval Air Warfare Center
RALCT	Risk and Lethality Commonality Team
RC	Risk Committee
RCC	Range Commanders Council
RSG	Range Safety Group
USAF	United States Air Force
USCG	United States Coast Guard
USC	United States Code
VAFB	Vandenberg Air Force Base
WR	Western Range
WSMR	White Sands Missile Range

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CHAPTER 1

INTRODUCTION

1.1 Purpose

This document provides a common set of range safety policies, risk criteria, and guidelines for managing risk to people and assets during manned and unmanned flight operations, excluding aviation operations. It establishes the following:

- a. Acceptable risk criteria for both the general public (involuntary acceptance) and mission essential personnel (voluntary acceptance).
- b. Debris injury thresholds for unprotected people.
- c. Debris hazard thresholds for aircraft and ships.
- d. Vulnerability models for large commercial transport aircraft.

1.2 Scope

The policies and criteria in this document are intended for use by members of the DoD national ranges and Major Range and Test Facility Base (MRTFB). These policies and criteria apply to launch and reentry hazards generated by endoatmospheric and exoatmospheric range activities including both guided and unguided missiles and missile intercepts, space launches, and reentry vehicles. This does not include aviation operations or UAV operations. The RCC Document 323-99 (Range Safety Criteria for Unmanned Air Vehicles) provides criteria for unmanned air vehicles.

1.3 Implementation

This document is an advisory document. Its content is based on the consensus positions held by the Risk Committee (RC) within the Range Safety Group (RSG), which is made up of a broad cross section of the US range safety community. Therefore, the content of this document represents consensus standards. The organization of this document conveys some of the level of imperative associated with the content. Consensus standards with the highest levels of priorities are generally provided in the main body of the document, while the supplement contains lower levels of priority requirements, guidelines, and example methods. However, precise language is used in both this document and the supplement in an attempt to capture the intent of the RC as follows:

- a. The words “must,” “shall,” and “will” indicate a requirement that is strongly recommended. Legitimate alternatives may exist, but each alternative either shall demonstrate an equivalent level of safety or be granted a waiver.
- b. "Should" indicates an advisory requirement or a highly desirable procedure. When this standard uses "should," the committee intends that a range will achieve compliance to the maximum extent practical, but no waiver or equivalent level of safety will be required.
- c. "Can" and "may" permit a choice and express a guideline.

In order for a range to effectively implement this document, the range should evaluate the contents of this document and incorporate it accordingly into its local regulations and requirements.

1.4 Range Responsibilities

Department of Defense Directive (DoD) Directive 3200.11, Major Range and Test Facility Base (MRTFB), assigns responsibility to each Range Commander for ensuring that all missions are conducted safely, consistent with operational requirements. Range flight operations typically involve some level of risk. Therefore, an important aspect of the range safety responsibility is to ensure that the risk is properly managed within prescribed limits. To accomplish this, each Range Commander (or designee) must:

- a. Establish risk management procedures (including hazard containment) to implement the risk management process described herein.
- b. Establish acceptable risk criteria appropriate to each type of mission flown in consideration of the guidance provided herein.
- c. Accept any risks, including those that exceed the established risk criteria when warranted for a mission in consideration of the operational requirements and national need.
 - (1) Make such decisions based on a thorough understanding of any additional risk that exceeds the risk criteria and the benefits to be derived from taking the additional risk.
 - (2) Ensure such decisions are documented in a formal waiver process (or equivalent), preferably in advance of the mission.
- d. Maintain related range policy and requirements documents.
- e. Maintain records of risk assessments and waivers to established risk criteria.
- f. For a mission involving more than one range, coordinate with the other range(s) to clearly document safety responsibility for each phase of the mission develop and implement joint plans for controlling the mission risk due to all planned and unplanned events.

CHAPTER 2

POLICIES AND PROCEDURES

2.1 General Policy and Goals

In planning any operation, risk must be reduced to the extent that is practical in keeping with operational objectives. Safety should be balanced with operational objectives by cooperative interaction between the range and the range user. To maximize achievement of mission objectives within safety constraints, the range user should consider overall risk along with other factors that affect mission acceptability. These factors include criticality of mission objectives, protection of life and property, the potential for high consequence mishaps, local political factors, and governing range or programmatic environmental requirements.

All ranges must strive to achieve complete containment of hazards resulting from both normal and malfunctioning flights. If a planned mission cannot be accomplished using a containment approach, a risk management approach may be authorized by the range Commander or the designated representative. The risk management approach should conform to the guidelines presented in this document or otherwise demonstrate compliance with the objectives presented.

Range Commanders should never regard events such as injuries as being routine or permissible. No adverse consequences are routinely acceptable; however, the probability is finite that range mishaps producing adverse consequences may occur. The term “acceptable risks” used in this document can be properly interpreted as “tolerable risks.” These are risks the range Commander may tolerate to secure certain benefits from a range activity with the confidence that the risk is properly managed within prescribed limits.

Compliance with this document leads to defensible launch support and launch commit decisions. Employing a sound basis for accuracy and repeatability in risk assessments leads to consistent risk acceptance decisions, thereby fostering public confidence that the ranges are operated with appropriate regard for safety. Thus, individuals living or working at or near a range may go about their daily lives without concern for their proximity to range activities. Moreover, compliance with these guidelines provides assurance that flights near or over communities by space boosters or weapon systems does not significantly increase the risk to these communities. These goals have led to the policy objectives provided here.

In defining objectives for risk assessment and risk management, the RCC goals are to:

- a. Create a uniform process among the ranges that will achieve the stated risk management goals.
- b. Promote accurate, repeatable risk assessments by minimizing errors in estimating and ensuring their scientific validity.
- c. Create a process that fosters innovation to support challenging missions.
- d. Nurture openness and trustworthiness among the ranges, range users and the public.

2.2 Policy Objectives

2.2.1 General Public. The general public includes all people located on and off base that are not essential to a specific mission or nearby critical operation. This definition applies to all people regardless of whether they are in some mode of transportation (such as airplanes, ships, and busses) are within a structure, or are unsheltered. The general public should not be exposed, individually or collectively, to a risk level greater than the background risk in comparable involuntary activities, and the risk of a catastrophic mishap should be mitigated.

In the above context, the RCC considers “comparable involuntary activities” as those where the risk arises from manmade activities that:

- a. Are subject to government regulations or are otherwise controlled by a government agency, and
- b. Are of vital interest to the US, and
- c. Impose involuntary risk of serious injury or worse on the public.

2.2.2 Mission Essential Personnel (MEP). A certain degree of risk is inherent in hazardous operations. The MEP Individuals should not be exposed, individually or collectively, to a risk level greater than that found in comparable high-risk occupations, and the risk of a catastrophic mishap should be mitigated.

2.2.3 Critical Operations Personnel (COP). The COP individuals include persons not essential to the specific operation or launch currently being conducted, but who are required to perform safety, security, or other critical tasks at the range. The critical operations range user (or manager) provides the number and justification of personnel required to conduct the critical operations. The range safety personnel will approve or determine the number and location of COP individuals with the concurrence of the appropriate Decision Authority. The COP individuals should be included in the same risk category as MEP personnel.

2.2.4 Catastrophe Potential and Transportation Systems. People on aircraft, ships, and other modes of transportation and people on oil rigs and offshore platforms should be protected to a level commensurate with the background risk associated with those activities. The risk assessment should account for potential catastrophic consequences to all exposed people and mitigations should be implemented to ensure that the risk from catastrophic events is consistent with the allowable risk given in paragraph [3.6.3](#) and paragraph [3.6.4](#).

Scenario-specific information should be considered in providing protection against catastrophic consequences. Combinations of factors that should be considered include the number of people who may be simultaneously injured, the risk of damage to high value assets, the risk of a casualty, factors that may significantly impair the range’s ability to perform its mission, and factors that may have national or international consequences.

Transportation systems include all modes of transportation such as airplanes, ships, trains, busses, and automobiles. People in transportation systems must be categorized following the same rules that apply to unsheltered people and people in fixed shelters (i.e., mission essential personnel (MEP), critical operations personnel (COP), or general public (GP). Each

individual in a transportation system must be protected to the level for his population category (MEP, COP, or GP). Collective risk must be assessed to include people in transportation systems. The collective risk to people in transportation systems must be added to the collective risk for unsheltered people and the collective risk for sheltered people. The numerical value defining the acceptability of the total collective risk must be based on the population category. Additional protection, such as defined in paragraph [3.6](#), must be applied to people in transportation systems in order to minimize the potential for catastrophic risk.

2.2.5 Spacecraft. Orbiting manned spacecraft will be protected to a level equivalent to that provided to mission essential aircraft. When the planned missions involve vehicles or propagated hazards with altitude capability greater than 150 km, ranges should coordinate with the 1st Space Control Squadron of the Air Force Space Command (AFSPC/1SPCS) for Conjunction Assessment if needed. In addition, ranges should establish Collision Avoidance periods in the launch window if there are any manned spacecraft within 50 km of, or lower than, the 3-sigma altitude capability of the launch vehicle, payloads, jettisoned objects or debris cloud boundary.

The Risk Committee recognizes that protection for critical unmanned space systems should also be provided; however, it is currently considered outside the scope of this safety standard. While DoD Directive (DoDD) 3100.10 states that DoD activities are to be conducted “...in a safe and responsible manner that protects space systems...,” it does not specify which DoD activity, the launching agency (range user) or the range, has the responsibility for assuring this protection.¹ Until responsibility is resolved by appropriate authorities, the Risk Committee recommends that the launching agencies and the ranges continue their current practices.

2.2.6 Environment. As part of environmental documentation preparation in compliance with federal and local regulations, launch and flight test hazards should be taken into account and mitigated as necessary. While safety is a factor in environmental compliance, environmental protection and regulation is beyond the scope of this standard.

2.3 Risk Management Process

Risk management is a systematic and logical process to identify hazards and control the risk they pose. This process should include the following elements (phases) which are depicted in Figure [2-1](#) and identified as:

<u>Phase</u>	<u>Title</u>	<u>Paragraph</u>
I	Mission Definition and Hazard Identification	2.3.1
II	Risk Assessment	2.3.2
III	Criteria Comparison and Risk Reduction	2.3.3
IV	Risk Acceptance	2.3.4

¹ Historically, protection of unmanned systems has been addressed as part of mission assurance by the launching agency but only for DoD missions or highly valued NASA missions. In the commercial space industry the launching agency retains liability insurance to cover such potential mishaps and has historically not utilized conjunction assessments for mission assurance or asset protection purposes.

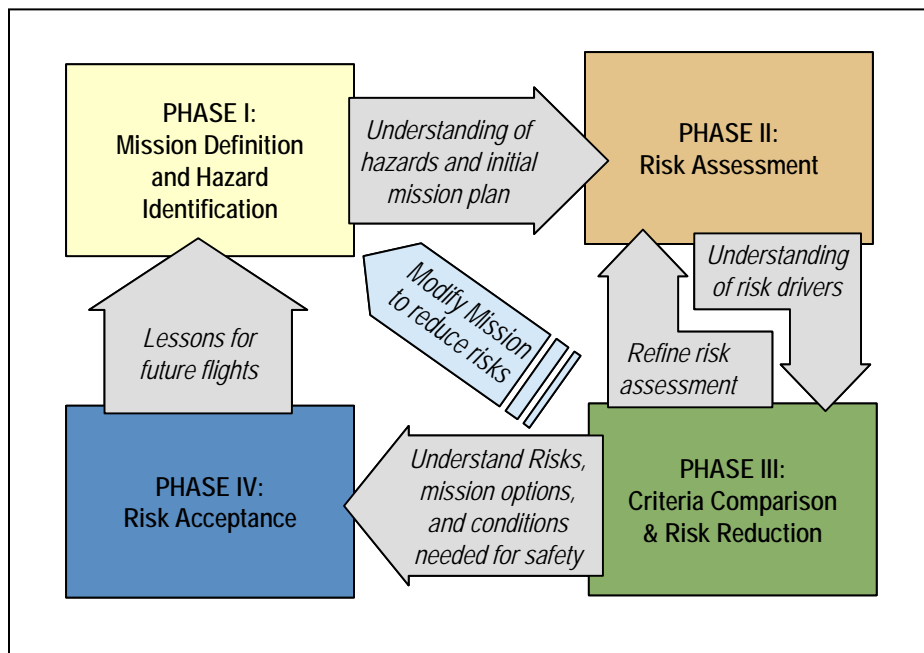


Figure 2-1. Risk management process.

The initial goal of the risk management approach is to contain the hazards and isolate them from populated areas wherever practical. An alternative to hazard isolation is to define hazard containment areas so as to minimize the population exposed or be able to evacuate persons not associated with the hazard-generating event. This is in accordance with the primary policy that no hazardous condition is acceptable if mission objectives can be attained from a safer approach, methodology, or position, i.e., minimizing the hazards and conducting the mission as safely as reasonably possible. When hazards cannot be contained or minimized to an insignificant level, then assessments that are more detailed are performed to determine if the remaining risk is acceptable. An additional benefit of hazard containment is that this process is typically less costly than risk assessments and can be evaluated relatively quickly with straightforward assumptions and with less required data.

2.3.1 Phase I: Mission Definition and Hazard Identification. Phase I is the “problem definition” step of the process. Information is assembled to identify mission characteristics, objectives, and constraints. Potential hazard sources must be identified by evaluating the system to be flown and the range safety constraints. Information sources typically include:

- a. Range safety data packages.
- b. System description documents.
- c. Mission essential and critical operations personnel locations.
- d. Surrounding population data to include public and commercial facilities and public and commercial transportation assets (including aircraft corridors and shipping lanes).
- e. Seasonal meteorological data.
- f. The range safety system used.
- g. Lessons learned on similar missions.

Further details of information sources are in Chapter 2 and Chapter 7 of the supplement to this document. The output of this step provides a basis for hazard analysis and risk assessment, and for use in evaluating options for mitigating risks in ways that will minimize adverse mission impact.

2.3.2 Phase II: Risk Assessment. This step provides information needed to determine whether further risk reduction measures are necessary. Risk levels for identified hazards are expressed using qualitative and quantitative methods. This step produces basic measures of the risks posed by hazards. These hazards include inert, explosive, and flammable debris dispersions, explosive overpressure fields, exposure to toxic substances, and exposure to ionizing and non-ionizing radiation. In some cases, this step will provide sufficient information to support the decision-making without further analysis.

A valid risk assessment must account for all potential hazards posed by the range activity to personnel, facilities, and other assets. The assessment must be based on accurate data, scientific principles, and an application of appropriate mathematics. The assessment must be consistent with the range safety control that is planned for the mission. Valid calculations to assess risk can be made using the methods presented in the supplement. These typically produce conservative estimates; i.e., they produce a scientifically plausible result that characteristically overestimates risk given existing uncertainties. In all cases, the analyst is responsible for ensuring that the application of the methods in the supplement produces reasonable results. This assessment leads to mitigation measures needed to protect individuals and groups of people; this topic is discussed more fully in Chapter [3](#).

In general, risk is expressed as the product of the probability of occurrence of an event and the consequences of that event. Total risk is the combination of the products, over all possible events, of the probability of each event and its associated consequence. The probability of an event is always between zero and one; however, the consequences of that event can be any value. Risk can be relatively high if the probability is high, or the consequence is great, or a combination of the two.

Simple risk models are often employed to make an initial determination of risk. They are also used when the identified hazards are known to result in low risks and the analyst is assured that the estimated risk is conservative. For example, simple models can be used when only inert debris occurs and the debris is fairly limited in size and weight, with relatively low values of kinetic energy or ballistic coefficients, and shelters would provide protection from debris. These models are generally less costly, minimize schedule impacts, and have the following characteristics:

- a. Simplified application of input parameters and assumptions.
- b. Simplified measures of population estimation utilized.
- c. A basic injury model and associated casualty areas.
- d. Conservative assumptions of debris fragmentation and survivability.

If the resulting risk estimate is conservative and well within acceptable limits, then models that are more costly and time consuming, more complex, or of higher fidelity, will not be necessary.

When the identified hazards are significant or the initial risk estimate shows that acceptance criteria are, or may be, exceeded, then more complex risk models are typically used. Use of these models may be more costly, be time consuming to execute, and require a higher fidelity and more sophisticated application of input data and assumptions. The assessment may require detailed population and sheltering models, more complex human vulnerability models, and more realistic debris fragmentation and survivability models. This may require input parameters and assumptions to be supported by empirical evidence or expert elicitation. The complex risk assessment models are typically used when significant size debris or explosive debris impacts are present that could compromise shelters and the associated population.

2.3.3 Phase III: Criteria Comparison and Risk Reduction. Risk measures are compared with criteria to determine the need or desirability for risk reduction. If the risk is initially unacceptable, measures should be considered to eliminate or mitigate it. Elimination is achieved by design or system changes that remove the hazard source; such as replacing a hazardous material with a non-hazardous one or moving a trajectory to achieve containment. Mitigation is achieved by reducing the consequences of an event or the probability of an event happening. For example, increasing system reliability of a launch vehicle or test article will increase the probability of success, thereby lowering risk. Alternatively, designing a mission to avoid flight over densely populated areas will decrease consequences of casualties and thereby reduce the risk. Mitigation measures may include elements in the operation plan that reduce risk and are consistent with operational objectives, flight termination systems, containment policies, evacuation, sheltering, and other measures to protect assets from the hazards. Flight termination criteria should be optimized by balancing the risk given a failure and termination against the risk given a failure and no flight termination. To evaluate the effectiveness of mitigation measures, risk must be reassessed assuming they have been implemented. These risk reduction procedures should be followed until risk levels are as low as reasonably practical.

2.3.4 Phase IV: Risk Acceptance. Presentations to the decision authority must be sufficient to support an informed decision. The presentations should include all range-mandated risk control measures, residual risks, measures of catastrophic loss potential (such as maximum collective risk given a flight termination action, maximum collective risk given failure of a flight termination system, and risk profiles), key analysis assumptions, and the protective measures that have been considered and implemented. The decision authority must approve proposed mission rules and should compare the operational risk to the criteria defined in this document and to other applicable mission requirements. When local agreements are in place and the range has adequately communicated the content and rationale of RCC Document 321 to the representatives of local government, local agreements should govern. This shall not be interpreted as overriding any Federal or state laws or regulations. The three-tiered hierarchy of requirements is:

- a. Federal and state laws and regulations.
- b. Local agreements.
- c. RCC Document 321.

In general, higher-risk operations require a higher level of approval. The Range Commander may tolerate risk levels within criteria given herein to secure certain benefits from a range activity with the confidence that the risk is properly managed and consistent with “best practices.” The outcome of these presentations to the decision authority is the acceptance of operational risks by a properly informed decision authority. This acceptance includes a determination that the residual operational risk is within tolerable limits. By doing so, it avers/justifies that the proposed conditions for allowing the operation to be initiated and the rules to allow the mission to continue to completion comply with “best practices” for ensuring that risk falls within accepted levels.

The terms of this acceptance and required implementation conditions must be documented. The responsible safety office should document a risk assessment to demonstrate compliance with the risk management policy applied.

2.4 Risk Uncertainty

The RSG Risk Committee recognizes that there is significant uncertainty in the computed risks of rocket launches. Ninety percent confidence bounds describing the uncertainty in the computed risk can have a range of several orders of magnitude. For this reason, uncertainty cannot be ignored. On the other hand, most of the current risk computation tools are not at a level where they compute uncertainty or where the uncertainty results can be trusted. This is a significant area to be addressed, but the schedule of the current RCC Document 321 standard did not allow for the considerable time required for the launch risk community to produce adequate modeling approaches that can respond to uncertainty requirements in risk acceptability. For this reason, this standard does not include uncertainty in the risk acceptability requirements, but it is understood that uncertainty will be addressed in future versions. In the meantime, the Risk Committee encourages the community to develop uncertainty models that can eventually be used with risk acceptability standards that require the use of uncertainty.

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CHAPTER 3

ACCEPTABLE RISK CRITERIA

This chapter defines acceptable risk criteria for people, aircraft, ships, and spacecraft that may be exposed to hazards associated with range flight operations. Hazard thresholds for people, aircraft, and ships are provided in Chapter 6 of the supplement.

There are two major components of the risk acceptability criteria: a set of performance standards for establishing and implementing appropriate risk criteria at a range, followed by a set of quantitative standards. The quantitative risk criteria contained in this chapter prescribe limits on a per mission and an annual basis. Chapter 4 of the supplement provides guidelines for establishing a risk budget for complex missions, such as those that involve multiple launches or distinct phases of flight. Chapter 4 also provides guidelines for implementation of these criteria, including annual risk management, catastrophe aversion, as well as protection of ships, aircraft, and manned spacecraft.

3.1 Performance Standards

Each range must:

- a. Assess the risk to all people from launch and reentry activities in terms of hazard severity and mishap probability. Note: Hazardous operations that can be contained within a controlled area may not require a risk assessment.
- b. Estimate² the expected casualties associated with each activity that falls within the scope of this document. Additional risk measurements may be useful for range operations that are dominated by fatality to ensure fatality risks do not exceed acceptable limits.
- c. Document its measure(s) of risk and risk acceptability policy in local requirements and policy documentation.
- d. Maintain documentation to demonstrate that its risk measures provide a complete and accurate assessment of the risks, to include documentation needed to demonstrate that its risk measures:
 - (1) Clearly convey the risk for decision makers.
 - (2) Are consistent with the measures used by other scientific or regulatory communities involved in “comparable involuntary activities” (as described in paragraph [2.2.1](#)).
- e. Estimate the risk on a per mission basis, except under special conditions where risk management on an annual basis is justified as described below.
- f. Periodically conduct a formal review to ensure that its activities and its mission risk acceptability policy are consistent with the annual risk acceptability criteria.

² The overall process is a risk assessment, but a particular value (i.e. a point estimate) is referred to as an estimate.

3.2 Personnel Protection

3.2.1 General Public.

- a. Individual Risk Criteria. Individuals must not be exposed to a probability of casualty greater than $1\text{E-}6$ for any single mission³. If fatality risks are also incorporated into the risk management process, then individuals must not be exposed to a probability of fatality greater than $0.1\text{E-}6$ ($1\text{E-}7$) for any single mission.
- b. Collective Risk Criteria. Collective risk for the general public must not exceed a casualty expectation of $100\text{E-}6$ ($1\text{E-}4$) for any single mission³. If annual risk is measured, collective risk for the general public should not exceed a casualty expectation of $3000\text{E-}6$ ($3\text{E-}3$) on an annual basis⁴. Risk management using only an annual measure of collective risk is only justified for range operations that occur frequently and pose low⁵ risk on a per mission basis. If fatality risks are also incorporated into the risk management process, then the collective risk for the general public must not exceed $30\text{E-}6$ ($3\text{E-}5$) expected fatalities for any single mission. If risk management using only annual risks is justified, and fatality risks are also incorporated into the risk management process, then the collective risk for the general public must not exceed $1000\text{E-}6$ ($1\text{E-}3$) expected fatalities on an annual basis.
- c. Catastrophic Risk Criteria. Catastrophic risk for the general public⁶ should not exceed the provisional⁷ criteria outlined in paragraph [3.6.3](#).

3.2.2 Mission Essential and Critical Operations Personnel.

- a. Individual Risk Criteria. Individual mission essential and individual critical operations personnel must not be exposed to a probability of casualty greater than $10\text{E-}6$ ($1\text{E-}5$) for any single mission. If fatality risks are also incorporated into the risk management process, then individual mission essential and critical operations personnel must not be exposed to a probability of fatality greater than $1\text{E-}6$ for any single mission.
- b. Collective Risk Criteria. Collective risk for mission essential and critical operations personnel must not exceed a casualty expectation of $300\text{E-}6$ ($3\text{E-}4$) for any single mission. If annual risk is measured, collective risk for mission essential and critical operations personnel must not exceed a casualty expectation of $30000\text{E-}6$ ($3\text{E-}2$) on an annual basis¹. Risk management using only an annual measure of collective risk is

³ If a flight operation creates a toxic risk, then the range must separately ensure the allowable level of risk enforced by them does not exceed other standards for toxic exposure limits for the general public when appropriate mitigations are in place. Chapter 8 of the Supplement provides an approach for implementing this requirement.

⁴ Chapter 4 of the supplement provides guidelines to assist in the implementation of annual risk management.

⁵ In this context, “low risk” means approximately two orders of magnitude below the per flight criteria for collective and individual risks.

⁶ This includes people in any transportation system, such as ships and aircraft, as described in Chapter 4 of the supplement.

⁷ The Risk Committee intends to investigate this further and the criteria are subject to change in the future.

only justified for range operations that occur frequently and pose low⁴ risk on a per mission basis. If fatality risks are also incorporated into the risk management process, then collective risk for mission essential and critical operations personnel must not exceed an expected number of fatalities of 300E-6 (3E-4) for any single mission. If risk management using only annual risks is justified, and fatality risks are also incorporated into the risk management process, then the collective risk for mission essential and critical operations personnel should not exceed 10000E-6 (1E-2) expected fatalities on an annual basis.

- c. Catastrophic Risk Criteria. Catastrophic risk for mission essential and critical operations personnel should not exceed the provisional criteria outlined in paragraph [3.6.4](#).

3.3 Aircraft Protection⁸

3.3.1 Non-Mission Aircraft Criteria.

- a. Non-Mission Aircraft Hazard Volumes. Non-mission aircraft will be restricted⁹ from hazard volumes of airspace where the cumulative probability of impact of debris capable of causing a casualty on an aircraft¹⁰ exceeds 0.1E-6 (1E-7) for all non-mission aircraft. As an alternative to protecting against a probability of impact, non-mission aircraft will be restricted from hazard volumes that exceed the individual risk criteria given in [3.2.1a](#) and the catastrophe criterion given in [3.6.3](#).¹¹
- b. Non-Mission Aircraft Risk Criteria. The individual and collective risks posed to the general public in any aircraft must comply with the criteria given in [3.2.1](#).

3.3.2 Mission Essential Aircraft Criteria.

- a. Mission Essential Aircraft Hazard Volumes. Mission essential aircraft will be restricted⁹ from hazard volumes of airspace where the cumulative probability of impact of debris capable of causing a casualty on an aircraft exceeds 1E-6 for all mission essential aircraft. As an alternative to protecting against a probability of

⁸ Chapter 4 of the supplement provides important guidelines on the proper implementation of aircraft protection measures.

⁹ In this context restricted from means that the range will (1) ensure that appropriate warnings/restrictions are issued through the FAA, and (2) not proceed with the hazardous activity if the range has knowledge that any aircraft hazard volume is violated.

¹⁰ Chapter 6 of the supplement provides threshold values to help define such debris.

¹¹ The supplement explains how hazard areas can be defined using probability of impact values and demonstrate compliance with 3.3.1.2. A range may prefer to use other methods that demonstrate compliance with the individual and collective risk criteria. In any case, the individual and collective risk criteria requirements always apply to all people, regardless of transportation mode.

impact, mission essential aircraft will be restricted from hazard volumes that exceed the individual risk criteria given in [3.2.1a](#) and the catastrophe criterion given in [3.6.4](#).¹²

- b. Mission Essential Aircraft Risk Criteria. The individual and collective risks posed to mission essential personnel in any aircraft must comply with the criteria given in [3.2.2](#).

3.3.3. Aircraft Hazard Volumes for Planned Debris Releases. The range must confirm that Notices to Airmen are issued that encompass the volume and duration necessary to protect from each planned debris release¹³ capable of causing an aircraft accident.¹⁴

3.3.4. Mishap Response. The range must coordinate with the FAA to ensure timely notification¹⁵ of any expected air traffic hazard associated with range activities. In the event of a mishap, the range must immediately inform the FAA of the volume and duration of airspace where an aircraft hazard is predicted.

3.4 Ship Protection¹⁶

The term "ship" includes boats and watercraft of all sizes.

3.4.1 Non-Mission Ship Criteria

- a. Non-Mission Ship Hazard Areas. Non-mission ships will be restricted¹⁷ from hazard areas where the probability of impact of debris capable of causing a casualty¹⁸ exceeds 10E-6 (1E-5) for non-mission ships. Non-mission ships should also be restricted from hazard areas where the cumulative probability of impact of debris capable of causing a catastrophic accident¹⁹ exceeds 1E-6 for all non-mission ships.

¹² The supplement explains how hazard areas can be defined using probability of impact values and demonstrate compliance with 3.3.2.2. A range may prefer to use other methods that demonstrate compliance with the individual and collective risk criteria. In any case, the individual and collective risk criteria requirements always apply to all people, regardless of transportation mode.

¹³ Planned debris releases includes intercept debris, jettisons stages, nozzle covers, fairings, inter-stage hardware, etc.

¹⁴ Federal law (49 CFR 830.2) defines an aircraft accident as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage." As described in the glossary, federal law also defines death, serious injury, and substantial damage for the purposes of accident reporting.

¹⁵ This may be accomplished through preflight analyses and coordination as described in Chapter 4 of the supplement.

¹⁶ Chapter 4 of the supplement provides important guidelines on the proper implementation of ship protection measures.

¹⁷ In this context restricted from means that the range will (1) ensure that appropriate warnings/restrictions are issued through the USCG or other appropriate authorities, and (2) not proceed with the hazardous activity if it has knowledge that any ship hazard area is violated.

¹⁸ This includes any debris capable of producing a casualty to an unsheltered person.

¹⁹ In the absence of valid ship vulnerability modeling, this includes any debris capable of deck penetration as described in Chapters 4 and 6 the supplement to this standard.

As an alternative to protecting against a probability of impact, non-mission ships will be restricted from hazard areas that exceed the individual risk criteria given in [3.2.1a](#) and the catastrophe criterion given in [3.6.3](#).

- b. Non-Mission Ship Risk Criteria. The individual and collective risks posed to the general public in any ship must comply with the criteria given in paragraph [3.2.1](#).

3.4.2 Mission Essential Ship Criteria.

- a. Mission Essential Ship Hazard Areas. Mission essential ships will be restricted¹⁷ from hazard areas where the probability of impact of debris capable of causing a casualty exceeds $100\text{E-}6$ ($1\text{E-}4$) for mission essential ships. Mission essential ships should also be restricted from hazard areas where the cumulative probability of impact of debris capable of causing a catastrophic accident exceeds $1\text{E-}5$ for all mission ships. As an alternative to protecting against a probability of impact, mission essential ships will be restricted from hazard areas that exceed the individual risk criteria given in paragraph [3.2.1a](#) and the catastrophe criterion given in paragraph [3.6.4](#).
- b. Mission Essential Ship Risk Criteria. The individual and collective risk posed to the mission essential personnel in any ship must comply with the criteria given in paragraph [3.2.2](#).

3.4.3 Ship Hazard Areas for Debris Releases. The range must confirm that notices to mariners are issued that encompass the area and duration necessary to protect from each planned debris impact capable of causing a ship accident.

3.4.4 Mishap Response. The range must coordinate with the USCG or other appropriate authorities to ensure timely notification of any ship traffic hazard associated with range activities. In the event of a mishap, the range must promptly inform the appropriate authority(s) of the area and duration of navigable waters where a ship hazard is predicted.

3.5 **Spacecraft Protection**

Manned spacecraft shall be protected by: (1) not exceeding a probability of impact greater than $1\text{E-}6$ per spacecraft, or (2) ensuring an ellipsoidal miss-distance of 200 km in-track and 50 km cross track and radially, or (3) ensuring a spherical miss-distance of 200 km. A spacecraft is considered manned if it is currently occupied, or expected to be occupied, and includes spacecraft en route to, and in support of, manned missions.

For objects (including launch vehicle, payload, jettisoned components, or planned debris) launched into a sustainable orbit, the duration of the conjunction assessment required for manned spacecraft protection shall be applied from launch through orbit insertion plus an analyst defined number of revolutions to account for (1) the type orbit the vehicle or component is injected into, operating in, or passing through, (2) its altitude exceeding the manned spacecraft altitude by the appropriate miss-distance, and (3) a sufficient time for the object to be catalogued. Prior coordination with 1st SPCS may allow an earlier time for the object to be catalogued and thereby result in a shorter duration for the conjunction assessment required to be performed for the

launch range. Besides the launch vehicle and payload, conjunction assessments must include all components jettisoned during the launch and intentionally propagated debris.

The vulnerability of the spacecraft must be accounted for in the risk assessment and the minimum debris size ascertained from the spacecraft operator whenever practicable. Otherwise, the spacecraft should be considered vulnerable to the current minimum debris size of 1mm or greater.

3.6 Catastrophic Risk Protection

Catastrophic risk criteria are designed to protect against scenarios involving numerous casualties. The following provisional catastrophic risk criteria are suggested guidelines to supplement the collective and individual risk criteria given in paragraph 3.2. Catastrophic risk assessments are especially useful for pre-flight analyses intended to evaluate and mitigate potentially catastrophic outcomes.

3.6.1 General. Missions must be permitted only when the catastrophic risks are consistent with the policy objectives given in paragraph 2.2.

3.6.2 Ship and Aircraft Hazard Areas. If ships and aircraft are excluded from the hazard areas designed to protect against excessive probability of impact limits provided in paragraph 3.3 and paragraph 3.4 in accordance with the guidelines set in Chapter 4 of the supplement, then the catastrophic risks to ships and aircraft are consistent with the policy objectives given in paragraph 2.2.

3.6.3 General Public Criteria. Catastrophic risks for the general public should not exceed the following provisional criteria:

$$P \times N^{1.5} \leq 10^{-4} \quad (\text{Eqn 3-1})$$

where

- | | |
|-----------|--|
| P | is the cumulative probability of all events capable of causing N or more casualties. |
| N | is number of casualties, based on the occupant load as defined in Table 3-1. |
| 10^{-4} | is the maximum acceptable expected casualties as defined in 3.2.1b. |

Figure 3-1 shows the relationship between P and N for the general public that satisfies this criterion.

**TABLE 3-1. DEFINITIONS USED TO DEFINE
TOLERABLE CATASTROPHIC RISKS**

Population Type	Catastrophic Outcome	Occupant Load (N)
Public Aircraft	An occurrence resulting in multiple fatalities ²⁰ , usually with the loss of the airplane ²¹	Maximum occupancy
Mission Essential or Critical Aircraft	An occurrence resulting in multiple fatalities, usually with the loss of the airplane	Expected occupancy
Public Ship	An occurrence resulting in multiple casualties, usually with loss of the ship	Maximum occupancy
Mission Essential or Critical Ship	An occurrence resulting in multiple casualties, usually with loss of the ship	Expected occupancy
Public Land Vehicle	An occurrence resulting in multiple casualties, usually with loss of the vehicle	Maximum occupancy
Mission Essential or Critical Land Vehicle	An occurrence resulting in multiple casualties, usually with loss of the vehicle	Expected occupancy
Public Train	An occurrence resulting in multiple casualties, usually with loss of the train	Maximum occupancy
Mission Essential or Critical Train	An occurrence resulting in multiple casualties, usually with loss of the train	Expected occupancy
Public Gatherings ²²	An occurrence resulting in multiple casualties	Maximum credible occupancy
Mission Essential or Critical Personnel Gathering	An occurrence resulting in multiple casualties	Expected occupancy

²⁰ FAA also has a formal definition for "severe consequence:" forced landing (which is also formally defined), loss of aircraft while occupants are on-board, serious injuries (as formally defined), or fatalities

²¹ FAA Advisory Circular 39-8

²² Public gathering places subject to catastrophic accidents include any locations where population concentrations may occur, such as schools, hospitals, stadiums, beaches, etc.

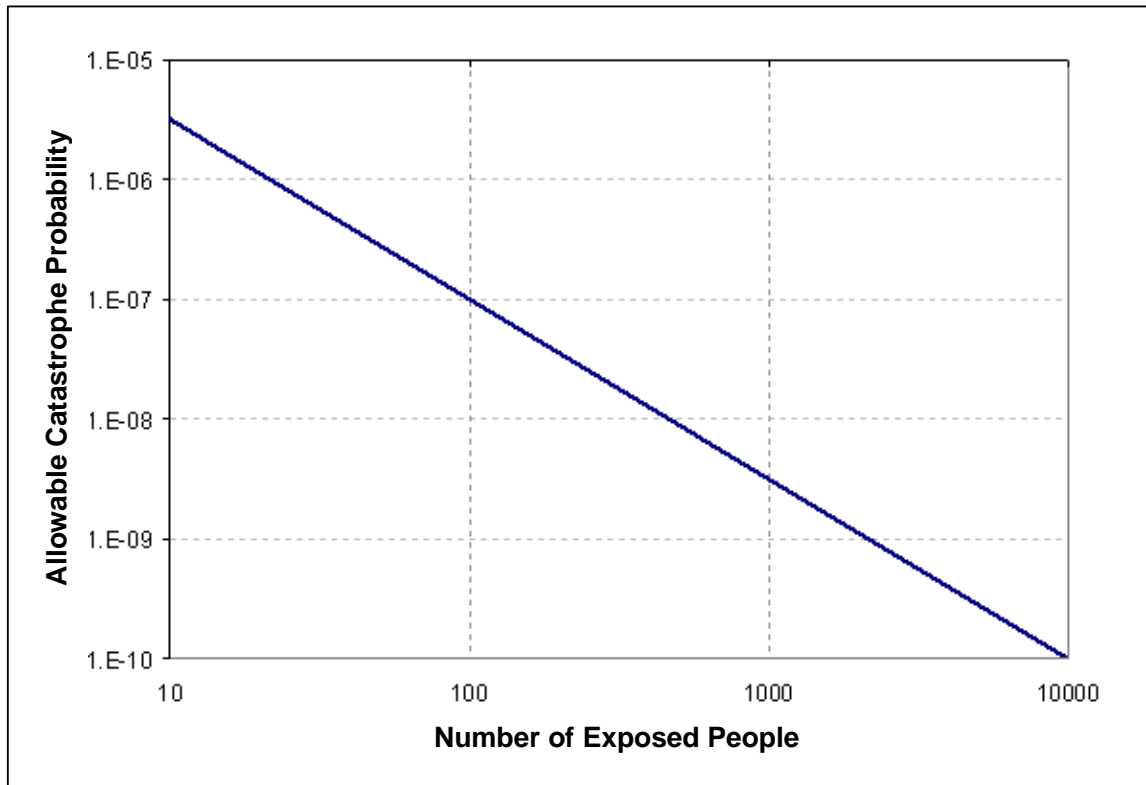


Figure 3-1. Tolerable catastrophe risks for the general public.

3.6.4 Mission Essential and Critical Operations Personnel Criteria. Catastrophic risks for mission essential and critical operations personnel should not exceed the following provisional criteria:

$$P \times N^{1.5} \leq 3 \times 10^{-4} \quad (\text{Eqn 3-2})$$

where

P is the cumulative probability of all events capable of causing N or more casualties.

N is number of casualties, based on the occupant load as defined in Table [3-1](#).

3×10^{-4} is the maximum acceptable expected casualties as defined in [3.2.2b](#).

3.7 Criteria Summary

Table [3-2](#) below summarizes the criteria defined by this document. All of the criteria are considered mandatory requirements except those highlighted by an asterisk, which are advisory requirements that may be considered mandatory under certain circumstances (as explained in Chapter 4 of the Supplement to this document).

TABLE 3-2. SUMMARY OF COMMONALITY CRITERIA				
General Public			Mission Essential and Critical Operations Personnel	
Per Mission	Max. Acceptable	Undesired Event	Max. Acceptable	Undesired Event
	1E-6 ^b	Individual Probability of Casualty	10E-6	Individual Probability of Casualty
	100E-6 ^b	Expected Casualties	300E-6	Expected Casualties
	0.1E-6 ^a	Individual Probability of Fatality	1E-6 ^a	Individual Probability of Fatality
	30E-6 ^a	Expected Fatalities	300E-6 ^a	Expected Fatalities
	0.1E-6	Probability of Aircraft Impact	1E-6	Probability of Aircraft Impact
	10E-6	Probability of Ship Impact	100E-6	Probability of Ship Impact
	- - -	- - -	1E-6	Manned Spacecraft
Annual	3000E-6	Expected Casualties	30000E-6	Expected Casualties
	1000E-6 ^a	Expected Fatalities	10000E-6 ^a	Expected Fatalities
^a Advisory Requirements. ^b If a flight operation creates a toxic risk, then the range must separately ensure the allowable level of risk enforced by them does not exceed other standards for toxic exposure limits for the general public when appropriate mitigations are in place. Chapter 8 of the Supplement provides an approach for implementing this requirement.				

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REFERENCES

- a. United States Code
 - 10USC Armed Forces
 - 28USC Part IV Judiciary and Judicial Procedures, Particular Proceedings (Federal Tort Claims Act)
 - 29USC Labor (Occupational Safety and Health Act)
- b. Department of Defense
 - DoD Directive 3100.10 Space Policy
 - DoD Instruction 3100.12 Space Support
 - DoD Directive 3200.11 Major Range and Test Facility Base
 - DoD Directive 4715.1 Environmental Security
 - DoD Instruction 6055.1 DoD Safety and Occupational Health Program
- c. Department of the Army
 - AR 385-10 The Army Safety Program
 - FM 100-14 Risk Management
- d. Department of the Air Force
 - AFI 90-901 Operational Risk Management
 - AFPD 91-2 Safety Programs
 - AFPD 63-12 Assurance of Occupational Safety, Suitability, and Effectiveness
 - AFPAM 90-902 Operational Risk Management Guidelines and Tools
- e. Department of the Navy
 - OPNAVINST 3900.39B Operational Risk Management
 - NPR 8715 NASA Procedural Requirements: Range Safety
- f. Range Commanders Council
 - RCC 316-98 Laser Range Safety
 - RCC 319-99 Flight Termination Systems Commonality Standard
 - RCC 323-99 Range Safety Criteria for Unmanned Air Vehicles
- g. Environmental Protection Agency
 - EPA 100-B-00-002 Risk Characterization Handbook

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GLOSSARY

3-sigma: Three times the standard deviation, typically referenced to the mean value.

Abbreviated Injury Scale (AIS): An anatomically based, consensus derived, global severity scoring system that classifies each injury in every body region according to its relative importance on a 6 point ordinal scale.

Acceptable risk: A predetermined criterion or standard for a maximum risk ceiling which permits the evaluation of cost, national priority interests, and number of tests to be conducted.

Accumulated risk: The combined collective risk to all individuals exposed to a particular hazard through all phases of an operation. Guidance Information is as follows:

- For the flight of an expendable orbital launch vehicle, risk should be accumulated from liftoff through orbital insertion.
- For the flight of a suborbital launch vehicle, risk should be accumulated from liftoff through the impact of all pieces of the launch vehicle, including the payload.

Aggregated risk: The accumulated risk due to all hazards associated with a flight. Guidance Information is that, for a specified launch, aggregated risk includes, but is not limited to, the risk due to debris impact, toxic release, and distant focusing of blast overpressure.

As Low As Reasonably Practicable (ALARP): That level of risk which can be lowered further only by an increment in resource expenditure that cannot be justified by the resulting decrement in risk. Often identified or verified by formal or subjective application of cost-benefit or multi-attribute utility theory.

Background Risk: risks voluntarily accepted in the course of normal activities.

Best practice: There are two definitions:

- A management idea which asserts that there is a technique, method, process, activity, incentive (or reward), that is more effective at delivering a particular outcome than any other technique, method, process, etc. The idea is that with proper processes, checks, and testing, a project can be rolled out and completed with fewer problems and unforeseen complications.
- An acceptable level of effort that represents the best choice available given the circumstances.

Casualty: A serious injury or worse, including death, for a human. For the purposes of this standard, serious injury is defined as Abbreviated Injury Scale (AIS) Level 3 or greater except where prior general practice at the range has been to protect to a lesser level of injury than AIS level 3, such as eardrum protection.

Casualty expectation: See *Expected Casualties*

Catastrophe: Any event that produces a large numbers of casualties or has a severe impact on continued range operations.

Clearance Zone: An area or volume from which objects at risk (people, ships, aircraft, etc.) are to be restricted or eliminated in order to control the risks.

Collective risk: The total risk to all individuals exposed to any hazard from an operation. Unless otherwise noted, collective risk is the mean number of casualties (E_C) predicted to result from all hazards associated with an operation. Collective risk is specified as either for a mission or per year. The collective risk should include the aggregated and accumulated risk.

Collision Avoidance (COLA): The process of determining and implementing a course of action to avoid potential on-orbit collisions with manned objects or with other specified orbiting objects. The process includes the determination of wait periods in either the launch window or spacecraft thrust firings based on validated conjunction assessments or risk analyses and accounts for uncertainties in spatial dispersions and arrival time of the orbiting objects and/or launch vehicle.

Conjunction Assessment (CA): The process of determining the point of closest approach of two orbiting objects, or between a launch vehicle and an orbiting object, in association with a specified miss-distance screening criteria or the corresponding probability of collision. Associated with the closest approach assessment is the closest approach distance, the times of launch or orbital firing that would result in the closest approach, and meeting the miss-distance or collision probability criteria.

Conservatism: As used in risk analysis conservative modeling, conservatism is a set of modeling assumptions that overstates the risk by overstating event probabilities, hazard probabilities, or consequences. Conservatism refers to the degree of overstating risk.

Containment: The launch safety strategy/process of minimizing risk to the maximum extent practical by keeping hazardous operations within defined hazard areas that are unpopulated or where the population is controlled and adequate protection can be provided to highly valued resources; to stop, hold, or surround a hazard.

Critical operations personnel: Critical Operations Personnel include persons not essential to the specific operation or launch currently being conducted, but who are required to perform safety, security, or other critical tasks at the range. To be treated as Critical Operations Personnel they must be notified of a neighboring hazardous operation and either trained in mitigation techniques or accompanied by a properly trained escort. Critical Operations Personnel do not include individuals in training for any job or individuals performing routine activities such as administrative, maintenance, or janitorial. Critical-Operations Personnel may occupy safety clearance zones and hazardous launch areas and may not need to be evacuated with the general public. Critical Operations Personnel should be included in the same risk category as Mission Essential Personnel.

Decision Authority: The Range Commander or senior official designated by the Range Commander to make risk decisions on his or her behalf.

Distant focusing: An atmospheric phenomenon that can produce greatly enhanced overpressure due to sonic velocity gradients with respect to altitude.

Endoatmospheric: Within the Earth's atmosphere; generally considered to be those altitudes below 100 km.

Exoatmospheric: Outside the Earth's atmosphere; generally considered to be those altitudes above 100 km.

Expected casualties: The mean number of casualties predicted to occur as a result of an operation if the operation were to be repeated many times. This risk is expressed with the following notation: $1\text{E-}7 = 10^{-7} = 1$ in ten million.

Expected fatalities: The mean number of fatalities predicted to occur as a result of an operation if the operation were to be repeated many times. This risk is expressed with the following notation: $1\text{E-}7 = 10^{-7} = 1$ in ten million.

Fatal injury: any injury that results in death within 30 days of the accident.

Fragmentation: The break up of an in-flight vehicle into fragments (components of the vehicle, pieces of the structure, chunks of solid propellant, miscellaneous hardware, etc.) due to explosive loads, aerodynamic and inertial loads, activation of a flight termination system, intercept with another vehicle, or impact on a surface.

Federal Tort Claims Act: A statute that limits federal sovereign immunity and allows recovery in federal court for tort damages caused by federal employees, but only if the law of the state where the injury occurred would hold a private person liable for the injury 28 USCA 2671-2680. Also FTCA.]

Fidelity: The accuracy of the representation when compared to the real world.

Flight Termination System (FTS): The airborne portion of the Flight Safety System. A flight termination system ends the flight of a vehicle and consists of the entire system on an airborne vehicle used to receive, decode, and execute the ground signals. It includes all wiring, power systems, and methods or devices (including inadvertent separation destruct systems) used to terminate flight.

General Public: People who are not declared/identified as mission essential personnel or critical operations personnel. This includes the public plus range personnel not essential to a mission, visitors, press, and personnel/dependents living on the base/facility.

Hazard: Any real or potential condition that can cause injury, illness, or death of personnel, or damage to or loss of equipment or property.

Hazard threshold: The lowest level at which adverse outcomes are expected to appear.

Hazard area: A geographical or geometrical surface area that is susceptible to a hazard from a planned event or unplanned malfunction.

Hazard volume: A geographical or geometrical volume of airspace that is susceptible to a hazard from a planned event or unplanned malfunction.

Hazardous operation: Those activities, which, by their nature, expose personnel or property to dangers not normally, experienced in day-to-day actions.

Impact: The impingement of a fragment on a surface, a structure, a person, or a vehicle.

Inadvertent Separation Destruct System (ISDS): a specialized form of ADS located on vehicle components that automatically activates when inadvertent separation of the component from the main vehicle is sensed. There is often a built-in delay included, in hope that the separated component will be sufficiently displaced at charge activation to preclude damage to the main vehicle.

Individual risk: Individual risk is the risk that a person will suffer a consequence. Unless otherwise noted, individual risk is expressed as the probability that an individual will become a casualty due to all hazards (P_C) from an operation at a specific location. Guidance Information is that:

- If each person in a group is subject to the same individual risk, then the collective risk may be computed as the individual risk multiplied by the number of people in the group.
- In the context of this document, individual risk refers to the probability that the exposed individual will become a casualty as a result of all hazards from a mission.

Informed decision: The “informed decision” principle is used in tort claims against the U.S. Government. The Federal Tort Claims Act (FTCA) enjoins the U.S. court system from second-guessing decisions made by properly authorized government officials in determining the acceptability of operational risks. A key test under the FTCA requires that the decision-making official be fully advised and informed of the known risks. Failure to fully advise the decision-making authority of known risks can result in liability of the U.S. Government or its officials.

Involuntary activity: No choice was made by the person affected which placed them in a position of increased risk; or the activity participated in or the item used was one that is generally done or used by more than 99% of the population. Examples: bathing, using coins, or drinking glasses.

Manned spacecraft: a spacecraft that is either currently occupied or intended to be occupied. Includes spacecraft en route to, and in support of, manned missions.

Mishap: An unplanned event or series of events resulting in death, injury, occupational illness, or damage to or loss of equipment or property or damage to the environment.

Mission: A flight test or operation. It may include multiple vehicles or all phases of the flight beginning with liftoff/launch. See the supplement Section 4.2.4 for details on defining a mission for risk assessment.

Mission essential: Those persons and assets necessary to safely and successfully complete a specific hazardous operation or launch.

Mission rules: Rules that define safety constraints and conditions and establish the boundaries within which the safety team operates. The lead safety organization develops the mission rules and briefs the range user to ensure a complete understanding of the intent and application of them. Mission rules are documented and become part of the range safety plan.

Overpressure: The pressure caused by an explosion over and above normal atmospheric pressure. It can be significantly affected by the atmospheric conditions, particularly the temperature and wind profiles.

Probability of casualty: The likelihood that a person will suffer a serious injury or worse, including a fatal injury, from a hazardous event. This risk is expressed with the following notation: $1\text{E-}7 = 10^{-7} = 1$ in ten million.

Probability of fatality: The likelihood that a person will die from a hazardous event. This risk is expressed with the following notation: $1\text{E-}7 = 10^{-7} = 1$ in ten million.

Prudent person: See *Reasonable Person*

Range Safety System (RSS): The ground-based portion of the Flight Safety System. An integrated system of hardware, software, and human operators which is necessary to provide mission safety support. Includes instrumentation and communication infrastructure needed to fulfill safety's flight control responsibility. See also *Flight Safety System* and *Flight Termination System*

Reasonable care: As a test of liability for negligence, the degree of care that a prudent and competent person engaged in the same line of business or endeavor would exercise under similar circumstances - Also termed due care; ordinary care; adequate care; proper care.

Reasonable person: A hypothetical person used as a legal standard, especially to determine if someone acted with negligence. The reasonable person acts sensibly, does things without serious delay, and takes proper but not excessive precautions. Also termed *Reasonable Man* or *Prudent Person*.

Reentry: The event occurring when a spacecraft or other object comes back into the sensible atmosphere after going to higher altitudes.

Risk: Risk is a measure that accounts for both the probability of occurrence and the consequence of a hazard to a population or installation. Unless otherwise noted, risk to people is measured in casualties and expressed as individual risk or collective risk.

Risk analysis: A study of potential risk under a given set of conditions. Risk Analysis is an activity that includes the complete array of tasks from data gathering, identification of hazards, estimation of associated risks, and verification of results.

Risk management: Risk management is a systematic and logical process to identify hazards and control the risk they pose.

Risk profile: A plot that shows the probability of an accident causing a given number of casualties (vertical axis) vs. the number of casualties (horizontal axis). The area under the plot is a measure of the casualty expectation. When a catastrophe-averse function is plotted on the same graph, the presence or absence of catastrophic risk is indicated.

Safety: Relative protection from adverse consequences.

Serious injury: Any injury that meets one or more of the following:

- Requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received.
- Results in a fracture of any bone (except simple fractures of fingers, toes, or nose).
- Causes severe hemorrhages, nerve, muscle, or tendon damage.
- Involves any internal organ.
- Involves second degree or third degree burns, or any burns affecting more than 5 percent of the body surface.

Ship Accident: A “ship accident” occurs if the vessel is involved in an accident that results in loss of life, personal injury that requires medical treatment beyond first aid, or complete loss of the vessel. This definition is consistent with the level of protection afforded people involved in a “boat accident” as defined in current regulations.

Sigma: Standard deviation.

Substantial damage: Relating to aircraft vulnerability means damage or failure that adversely affects the structural strength, performance, or flight characteristics of the aircraft, and that would normally require major repair or replacement of the affected component.

Toxic substance: A chemical or mixture that may present an unreasonable risk of injury to health or the environment.

Toxics: A Generic term for the toxic propellants and combustion by-products resulting from a nominal launch vehicle flight or catastrophic launch abort.

Uncertainty: The absence of perfectly detailed knowledge. Uncertainty includes incertitude (the exact value is unknown) and variability (the value is changing). Uncertainty may also include other forms such as vagueness, ambiguity, and fuzziness (in the sense of borderline cases).

Variability: Observed differences attributable to true heterogeneity or diversity. Variability is the result of natural random processes and is usually not reducible by further measurement or study (although it can be better characterized).

Verification: refers to the set of activities that ensure that software correctly implements a specific function. The verification process determines whether a computer simulation code for a particular problem accurately represents the solutions of the mathematical model. Evidence is collected to ascertain whether the numerical model is being solved correctly. This process ensures that sound software-quality practices are used and the software codes themselves are free of defects and errors. It also checks that the code is correctly solving the mathematical equations in the algorithms and verifies that the time and space steps or zones chosen for the mathematical model are sufficiently resolved.

Voluntary activity: The person affected made a choice that placed them in an increased position of risk compared to the rest of the population. This includes career and job choices. Examples include repetitive motion injuries, recreational boating, etc.